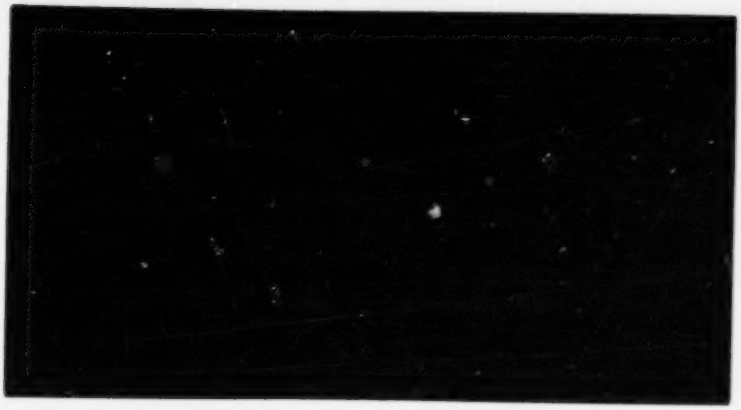

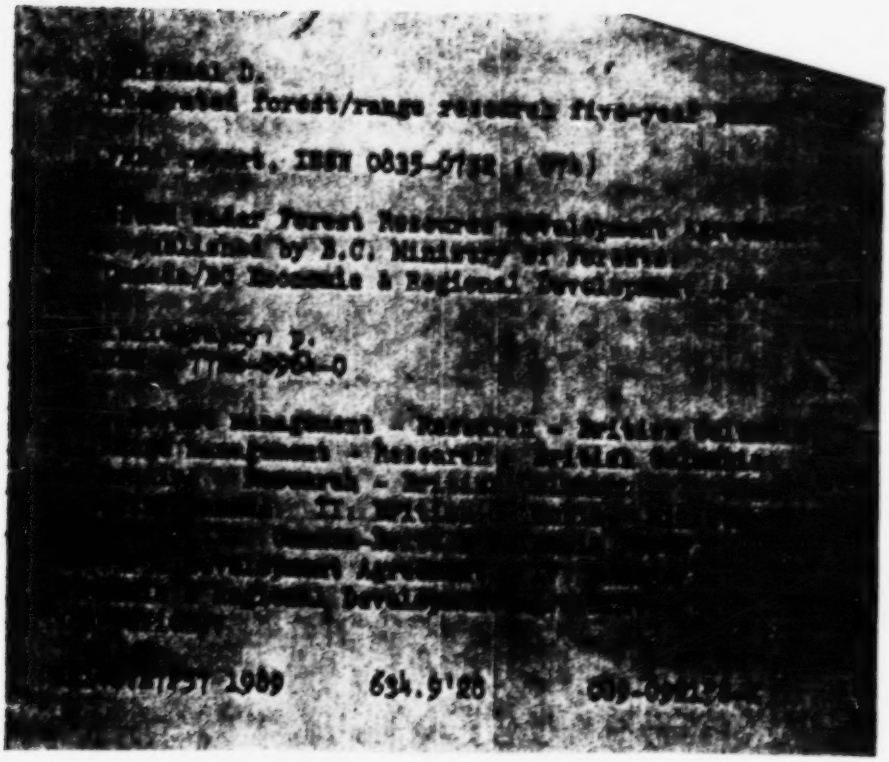

Integrated Forest/Range Research
Five-year Plan

by

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EXECUTIVE SUMMARY

The primary objective of this report is to recommend a 5-year plan for research which will (1) clarify the biological interactions among grass, trees, and cattle, relative to backlog NSR, and (2) provide reliable information to assist resource managers with integrated forest and range management in the Cariboo, Kamloops, and Nelson Forest Regions. The recommendations are based on site visits, personal interviews, and review of literature and internal government reports.

Potential research topics identified during the investigation generally confirmed previous recommendations for the kinds of research programs that are most pertinent to grass/tree/cattle interactions in British Columbia. Research priorities were reached according to the following criteria:

- The research addresses issues of controversy among resource managers.
- The research provides information directly pertinent to forest backlog problems.
- The research improves operational backlog forestry by identifying silvicultural obstacles to reforestation.
- The research demonstrates reforestation programs at field locations.
- The research supports current investigative programs by providing information currently lacking or incomplete.

In order of priority, the recommended research topics are:

1. Research and Demonstration of the Impacts of Operational Cattle Grazing and Forage Seeding on Reforestation.
2. Effects of Basal Scarring and Shoot Damage on Lodgepole Pine and Spruce Seedling Survival and Growth.
3. The Effects of Grazing Pressure on Conifer Seedling Damage.
4. Effects of Forest Herbicides on Survival and Production of Key Herbaceous Species.
5. The Effects of Cattle Grazing and Forage Seeding Rates on the Survival and Growth of Conifers and Control of Native Vegetation.

To promote success of these projects, research should begin only after detailed working plans have been completed. Working plans should identify specific research objectives, statistical hypotheses, experimental design, proposed statistical analyses, specific research sites, projected budget, and anticipated results. All working plans should be approved by a committee consisting of agrologists, graziers, private foresters, scientists, and silviculturalists. This approach ensures that the research will satisfy scientific credibility while still producing information with practical application.

The research and demonstration projects should occur primarily in the Kamloops Forest Region, where the interactions among grazing, seeding of domestic forages, and forestry are most intense. Demonstration projects, however, should also be conducted in the Cariboo and Nelson Forest Regions to provide geographical and ecological breadth, and increased accessibility to demonstration sites throughout the southern Interior. Forest backlog and grazing interactions are most prevalent in the dry subzones of the ESSF, IDF, ICH, and MS biogeoclimatic zones, which should receive priority as research sites. Wherever possible, new projects should be co-ordinated with existing operational and research investigations.

Virtually all interviewees identified operational studies as the most useful approach to address grass/cattle/tree interactions. Such demonstration projects, however, must also be supplemented with replicated experiments to provide credible information that can be used reliably by resource managers. Such reliable information, disseminated through reports, workshops, and field days, will enhance communication
among resource managers. Improved communication, based on conclusive research, is essential if integrated forest and range management is to be successful.

ACKNOWLEDGEMENTS

Many individuals and government agencies contributed to this report, as indicated by the list of interviewees in Appendix 1. The time, effort, and candour exhibited by all these individuals and groups are sincerely appreciated. Special thanks are extended to Dr. Brian M. Wikeem and Mr. Phil Youwe, who supervised the project, organized site visits, and contributed significantly to the interpretations and recommendations contained in this report.

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1 INTRODUCTION

The British Columbia *Forest Act*, revised statutes of British Columbia, 1979, Chapter 272, directs the Ministry of Forests to "encourage maximum productivity of the forest and range resources in the Province" (Section 4a); and to "plan the use of the forest and range resources of the Crown, so that the production of timber and forage, the harvesting of timber, the grazing of livestock and the realization of fisheries, wildlife, water, outdoor recreation and other natural resource values are coordinated and integrated, in consulta-tion and cooperation with ministries and agencies of the Crown and with the private sector" (Section 4c).

In keeping with these multiple use objectives, current ministry policy is to seed harvested or burned forest land with forage plants, particularly where the ranching industry is locally important, so as to provide a consistent source of high-quality forage (B. C. Min. For. 1985b). This policy supports seeding practices that have occurred throughout the southern Interior (according to regional and district priorities) since the 1960's (McLean and Clark 1980).

Multiple use objectives occasionally place alternative resource values in conflict. Seeding of harvested or disturbed forest lands to domestic forages, followed by livestock grazing of that forage, may result in damage, reduced growth, or mortality of regenerating trees. These undesirable results of seeding and livestock grazing may also contribute to the length of time that disturbed forest lands remain classified as Not Satisfactorily Restocked (NSR). Depending on regional criteria, areas that remain NSR, usually (5-7 years) are then classified as backlog, which requires either a reduction in projected annual allowable cuts, or planting of trees to bring the land back into forest production.

Many factors contribute to forest lands remaining classified as backlog or NSR, including logging and site preparation techniques, quality of planting stock, and environmental conditions following disturbance. Competition with seeded forages and damage to trees from livestock further constrain successful regeneration of the new forest crop.

Such constraints notwithstanding, research by McLean and Clark (1980) near Kamloops concluded that domestic forages and cattle grazing on clearcuts could be compatible with regenerating trees, assuming there was proper management. Although potential compatibility among cattle, grass, and trees is generally accepted in principle by many resource managers, some remain skeptical about the extrapolation of McLean and Clark's (1980) recommendations to other biogeoclimatic zones and management programs. Much of this skepticism results from inconclusive information from other forest study sites, as well as from conflicting operational results among clearcuts seeded to tame forages and/or grazed by cattle. This document, based on an analysis of existing information and personal interviews, recommends a 5-year plan to mitigate these biological uncertainties.

2 OBJECTIVES AND METHODS

The primary objective of this study was to develop a 5-year plan for research which will (1) clarify the biological interactions among grass, trees, and cattle; and (2) provide reliable information to assist resource managers with integrated forest management on forest land in the Cariboo, Kamloops, and Nelson Forest Regions. Research programs most likely to achieve these two goals are identified and ranked in priority. Strategies for pursuing potential research programs are recommended, including administration, participants, and locations of suggested research. This research intends to assist and promote integrated forest and range management, particularly that aimed at reducing backlog reforestation. Specific terms of reference include:

1. Re-evaluate and update previous grass/tree/cattle interaction research from the perspective of the backlog reforestation problem, by:
    - reviewing research recommendations from southern Interior (Nelson, Kamloops, Cariboo) Regional Research Advisory Committee meetings, problem analyses, literature reviews, the Forest and Grazing Task Force Report, and other relevant material on interactions between silviculture and range activities on forest land in British Columbia;

- reviewing relevant grass/tree/cattle literature pertaining to backlog reforestation published since Nordstrom's (1984) Land Management Report No. 19;
- producing a list of grass/tree/cattle research topics that have been identified through all sources;
- interviewing key persons in industry and government agencies provided by the contract supervisors to re-affirm research priorities and to determine if new problems have emerged since early priority lists were established;
- inspecting clearcut sites used for grazing, including those with and without backlog reforestation problems; and
- providing an updated list of grass/tree/cattle interaction priorities with rationale for each.

2. In consultation with the contract supervisors, prepare a 5-year plan for grass/tree/cattle studies in the southern Interior.

2.1 Methods

This report is based on personal interviews and a review of literature and internal government reports. The initial list of interviewees, provided by the contract supervisors, included as many people as possible within government and the private sector. During all interviews, individuals were asked to comment on specific questions, and as well were encouraged to provide personal experiences with grass/tree/cattle interactions.

Most of the interviews occurred during site visits of clearcuts in the Kamloops, Merritt, Penticton, and Vernon Districts of the Kamloops Forest Region. Interviews of personnel in the Cariboo and Nelson Forest Regions were conducted by telephone.

Interviews, site visits, literature reviews, and government reports were evaluated so that a consensus could be developed of the kinds and extent of research that would most likely promote positive grass/tree/cattle interactions in the southern Interior. The final recommendations for research projects represent the author's assessment of that consensus.

Undoubtedly, many individuals other than those listed in Appendix 1 could have provided valuable comments and perspectives about grass/tree/cattle interactions. Unfortunately, available time constrained the total number of personal interviews possible. The Ministry of Forests welcomes all additional comments on this report.

3 GRASS/TREE/CATTLE INTERACTIONS IN THE SOUTHERN INTERIOR

The following sections summarize the data collected for total backlog and NSR forest lands in the Cariboo, Kamloops, and Nelson Forest Regions, concerning total annual logging, tree planting, grass seeding, and cattle grazing. Wherever possible, this information has been provided for each biogeoclimatic zone within forest regions.

3.1 Extent of Backlog

Table 1 summarizes estimates of NSR lands which are now classified as backlog, based on summaries from History of Crop Establishment records (in Vyse 1986). This summary indicates that approximately one-third (36%) of all backlog NSR occurs in the ESSF biogeoclimatic zones, while the ICH accounts for an additional 24% of backlog NSR. The IDF biogeoclimatic zone likely contains less than 24% of total backlog NSR, as the quantity of NSR lands in this zone in the Cariboo Forest Region is exaggerated because of inappropriate survey techniques (Vyse 1986). The MS (10%) and SBS (4%) zones account for much smaller proportions of total backlog NSR in the southern Interior.

TABLE 1. Distribution of 1986 backlog NSR by biogeoclimatic zone (Vyse 1986)

Region	Biogeoclimatic Zone						
	ESSF %	ICH %	IDF %	MS %	SBS %	Other %	Total ha
Cariboo[a]	12	12	46	1	25	4	36 287
Kamloops	37	18	29	13	2	1	185 684
Nelson	40	36	12	9	-	3	140 710
All regions	36	24	24	10	4	2	362 681

[a] Data for the Cariboo Region include only the 100 Mile and Williams Lake Timber Supply Area (Vyse 1986).

Discussions during the field trip suggested that even within biogeoclimatic zones, the distribution of backlog and NSR sites varied according to available soil moisture. In general, the dry subzones of each biogeoclimatic zone suffered greater regeneration problems, and had correspondingly higher proportions of backlog and NSR.

Trends in the amount of land classified as NSR are difficult to define explicitly because "NSR forest land is a dynamic medium with continuous inflows and outflows ... which only reflect the situation at a specific point in time..." (B. C. Min. For. 1984a). Variable survey techniques, sampling methods, management criteria, and increased survey coverage further complicate comparison of NSR data among years (B. C. Min. For. 1984a). Reflecting these constraints, Table 2 shows that the total area of NSR in the Kamloops Forest Region increased between 1979 and 1986, but declined in the Cariboo and Nelson Forest Regions during the same period (Table 2).

TABLE 2. Hectares of NSR/DSD/NCBr on Crown lands, TFL's, and timber licences

Region	1979[a]	1983-1984[b]	1984-1985[c]	1985-1986[d]
Cariboo	174 400	174 400	158 000	158 000
Kamloops	150 400	150 400	194 000	194 000
Nelson	262 800	262 800	244 000	244 000
Total	587 600	587 600	596 000	596 000

[a] B. C. Min. For. 1984a:C10.
[b] B. C. Min. For. 1984b:Table 6.
[c] B. C. Min. For. 1985a:Table 6.
[d] B. C. Min. For. Lands 1986:Table 6.

Trends in NSR between 1979 and 1986 (Table 2) should not be considered conclusive. For example, the data in Table 2 explicitly include Disturbed-Stocking Doubtful (DSD) and Non-Commercial Brush (NCBr) in addition to NSR. The DSD lands would presumably be classified as NSR if the sites were inventoried, whereas the NCBr lands might not necessarily be listed as NSR, depending on regional criteria (J. Hilton, pers. comm., B.C. Min. For., Williams Lake). It is apparent that these criteria vary among inventory programs and personnel, as the estimate of NSR provided by Vyse (1986) in Table 1 for the Nelson Forest Region differs substantially from the estimate in Table 2.

3.2 Extent of Logging

Table 3 summarizes hectares of logged area between 1978 and 1984. Highest average annual harvested area occurred in the Cariboo Forest Region (28 300 ha), followed by the Kamloops (24 800 ha) and Nelson (20 000 ha) Forest Regions. The approximate proportion of NSR lands to annual harvested area was 5.6, 7.8, and 12.2% in the Cariboo, Kamloops, and Nelson Forest Regions, respectively. Table 4 indicates that logging occurs in a wide variety of biogeoclimatic zones, and that total volume harvested is approximately equally distributed among the three forest regions.

TABLE 3. Average area (ha) harvested: clearcut and selective logging (B. C. Min. For. 1984a:C2)

Forest Region	Year						Average
	1978-79	1979-80	1980-81	1981-82	1982-83	1983-84	
Cariboo	26 600	28 537	33,008	23 978	29 959	27 935	28 300
Kamloops	24 727	25 835	26 408	19 894	21 942	30 182	24 800
Nelson	19 592	22 261	22 405	15 739	20 064	19 877	20 000

TABLE 4. Timber harvest ('000 m^3) within biogeoclimatic zones by forest region in the southern Interior in 1980 (Nordstrom 1984:9)

Forest Region	Biogeoclimatic zones	Timber harvest
Cariboo	AT, ESSF, ICH, IDF, MS, PPBG, SBS	6 913
Kamloops	AT, ESSF, ICH, IDF, MS, PPBG	8 251
Nelson	ESSF, ICH, IDF, MS, PPBG	5 962
Total		21 126

3.3 Relationships Among Grazing, Reforestation, and Backlog

Following logging, a new forest crop may be initiated by a variety of silvicultural techniques, including site preparation, planting, and natural regeneration. Site preparation, including broadcast burning, piling and burning, mechanical scarification, and specialized machinery, occurs on approximately 43% of annually logged areas in the Cariboo and Nelson Forest Regions, and 62% of logged areas in the Kamloops Forest Region (Tables 3 and 5). Based on yearly averages, approximately 69% of prepared sites were planted to trees in the Kamloops Forest Region, followed by the Nelson (66%) and Cariboo Forest Regions (51%) (Tables 5 and 6). The average annual proportion of logged areas planted to trees is highest in the Kamloops Forest Region (43%), followed by the Nelson (29%) and Cariboo (22%) Forest Regions.

TABLE 5. Annual (ha) site preparation for planting and natural regeneration (B. C. Min. For. 1984a:C13)

Forest Region	Year					Average
	1979-80	1980-81	1981-82	1982-83	1983-84	
Cariboo	7 722	18 365	5 892	17 951	11 897	12 365
Kamloops	11 320	14 830	13 249	12 804	24 902	15 421
Nelson	9 560	9 271	4 300	7 593	12 720	8 689

TABLE 6. Area (ha) planted annually on Crown land (B. C. Min. For. 1984a:C15)

Forest Region	Year					Average
	1979-80	1980-81	1981-82	1982-83	1983-84	
Cariboo	5 351	5 772	7 514	7 419	5 483	6 308
Kamloops	6 671	6 483	9 984	15 073	15 336	10 709
Nelson	5 119	5 907	6 103	6 132	5 352	5 723

3.3.1 Influence of grazing activities on reforestation and backlog

In 1983, 924 122 Animal Unit Months (AUM's) of grazing occurred on Crown range in British Columbia, including 78 585, 343 941, and 360 295 in the Nelson, Kamloops, and Cariboo Forest Regions, respectively (B. C. Min. For. 1984a:D10). Table 7 shows that most biogeoclimatic zones in the southern Interior are used for livestock grazing which is almost entirely by cattle.

Of the 5.9 million ha of forest land in the Cariboo Forest Region, approximately 37% (2.2 million ha) are used for grazing, followed by 29% in the Kamloops Forest Region (1.3 million ha grazed of 4.4 million ha of forest land), and 8% in the Nelson Forest Region (0.3 million ha grazed of 3.9 million ha of forest land) (B.C. Min. For. 1984a:D9; B. C. Min. For. Lands 1986: Table 6). Provincially, however, only 11 million ha of forest land are available for livestock use, of which 75% (8.3 million ha) was allocated for grazing in 1981 (B. C. Min. For. 1984a:G3).

TABLE 7. Biogeoclimatic zones used by livestock in the Nelson, Kamloops, and Cariboo Forest Regions (Wikeem 1983)

Biogeoglimatic zone	Forest Region		
	Nelson	Kamloops	Cariboo
Alpine Tundra (AT)		x	x
Boreal White/Black Spruce (BWBS)			
Engelmann Spruce/Subalpine Fir (ESSF)	x	x	x
Interior Cedar Hemlock (ICH)	x	x	x
Interior Douglas-Fir (IDF)	x	x	x
Montane Spruce (MS)	x	x	x
Ponderosa Pine/Bunchgrass (PPBG)	x	x	x
Sub-Boreal Spruce (SBS)			x

The most extensive grazing use of available Crown range is being made on open range, clearings, and ponderosa pine forest. Substantial portions of deciduous forest and dry forest are also being grazed (Table 8). In the Kamloops Forest Region, open range is grazed most intensively, followed by ponderosa pine forest, transitional areas, and clearings, respectively.

TABLE 8. Percent grazing use of available Crown range

General range type	All Forest Regions[a]	Kamloops Forest Region[b]
Open Range	65	74
Wetland	16	22
Alpine	1	17
Ponderosa Pine Forest	55	55
Dry Forest	34	39
Lodgepole Pine Forest	19	26
Wet Forest	3	3
Deciduous Forest	37	33
Transitional	22	48
Clearings	57	44
Non-Vegetated	-	-
Brush	21	-
Urban	25	20
Alienated	-	1

[a] B.C. Min. For. (1984a:D13).
[b] P. Youwe (pers. comm.).

Livestock production on clearcuts may be enhanced by seeding to domestic forages following logging. Table 9 summarizes hectares of disturbed forest land, including clearcuts, seeded to domestic forages between 1982 and 1986 in the southern Interior. Clearly, the greatest total area of seeding to domestic forages occurs in the Kamloops Forest Region (5 620 ha/year), followed by the Nelson (2 498 ha/year) and Cariboo (1 419 ha/year) Forest Regions, respectively.

The values in Table 9 likely underestimate total land area seeded to domestic forages, as they may not include specific seeding programs on landings and skid trails, carried out by MoF staff, timber licensees, and ranchers. Moreover, no specific information is easily available that indicates what proportion of seeded land summarized in Table 9 occurred specifically on clearcuts. Generally, however, seeded areas represented approximately 26% of the total hectares clearcut in the Kamloops Forest Region between 1982 and 1986, followed by 19% in the Nelson Forest Region, and only 7% in the Cariboo Forest Region.

3.3.2 Proportion of NSR and backlog caused by grazing activities

Despite the information presented in Tables 7-9, no data are readily available which summarize the specific proportion of NSR forest sites that have been seeded and/or grazed by cattle. For example, grazing summaries are categorized by General Range Types, which do not correspond directly with biogeoclimatic zones that are used to categorize timber and NSR statistics. Undoubtedly, however, those areas where cattle grazing may contribute to NSR problems most likely occur on clearcuts, particularly those seeded to domestic forages. All clearcuts less than 20 years old are classified as Transitional, a General Range Type that is commonly grazed by cattle (Table 8).

TABLE 9. Hectares of clearcut and seeded forest land in the Cariboo, Kamloops, and Nelson Forest Regions between 1982 and 1986 (Nordstrom 1984:6; B. C. Min. For. 1984b, 1985a; B.C. Min. For. Lands 1986)

Forest Region	Clearcut (ha)	Seeded (ha)[a]	% of area seeded
Cariboo			
1982-1983	16 104	224	1.4
1983-1984	20 370	1 708	8.4
1984-1985	24 612	1 501	6.1
1985-1986	31 757	2 243	7.1
Total	92 843	5 676	6.1
Kamloops			
1982-1983	14 041	8 436	60.1
1983-1984	21 876	1 043	4.8
1984-1985	24 452	7 562	30.9
1985-1986	26 325	5 437	20.6
Total	86 694	22 478	25.9
Nelson			
1982-1983	8 826	1 300	14.7
1983-1984	13 456	2 552	19.0
1984-1985	14 308	2 075	14.5
1985-1986	16 825	4 067	24.2
Total	53 415	9 994	18.7

[a] Seeding on disturbed forest land, including clearcuts.

Although cattle grazing and seeding domestic forages on clearcuts potentially add to NSR and backlog forest problems, the magnitude of the effect of these two factors remains undocumented. Nonetheless, several obvious interactions are known to occur between grazing and silviculture. Cattle damage to trees may occur by direct browsing, although basal scarring and leader damage by coincidental trampling are more common sources of damage (Banks 1986). These wounds can cause mortality, reduce tree growth rates, and lengthen the time required for the tree to reach the free-to-grow stage (Lewis 1980; Sullivan and Sullivan 1982; Sullivan 1984). Trampling damage may be exacerbated by some silvicultural techniques such as trenching, which provides ready-made trails for cattle. Alternatively, cattle grazing may also improve tree growth and survival rates by reducing herbaceous plant competition, and by reducing the amount of grass available for lodging on trees during winter.

Silvicultural and logging activities may also produce desirable or undesirable effects on cattle production and grazing opportunities. Logging may remove traditional grazing areas and travel corridors. These forest grazing areas often provide nutritious forage, particularly where pinegrass is naturally supplemented with a diversity of other herbaceous and woody plants. The forest canopy may also prolong plant growth, giving plants better nutritive quality than those growing in direct sunlight.

Alternatively, seeding clearcuts to domestic forages increases forage production per hectare; may improve forage nutritive quality and palatability compared to that of native forage (McLean and Clark 1980); and provides an opportunity for easier control of cattle, which tend to congregate on seeded areas. These improved forage and grazing management opportunities may also increase cattle weight gains during the summer grazing period compared to that which occurs on unimproved forest grazing land.

3.3.3 Opportunities for integrated management

Several examples illustrate that successful integration of cattle and timber production is possible. McLean and Clark (1980) documented that cattle damage to naturally regenerating lodgepole pine and Engelmann spruce was negligible where numbers and movements of cattle were strictly controlled. Tree damage and mortality were confined primarily to accidental trampling rather than direct browsing. Moreover, tree stocking rates, even with cattle-induced mortality, remained above optimal levels. Total tree mortality from grass competition, compared to natural mortality, was negligible, except where grass was very dense. McLean and Clark (1980) hypothesized, from their observations, that competition to trees from native vegetation was usually as severe as the competition from seeded forages.

Similar examples of successful integrated management have been reported in Oregon. Monfore (1983) mitigated cattle damage to regenerating ponderosa pine by grazing more livestock earlier in the season. This early grazing, before the flush of tree growth, encouraged cattle to graze preferentially on native grasses rather than on trees. Intense, uniform grazing promoted a continuous regrowth of herbaceous forage, which maintained livestock attention on key forage plants, and away from tree seedlings.

Similarly, Krueger (1983) reported that trampling by cattle, grazing under experimental conditions, accounted for only 8% of total tree seedling mortality, compared to >50% caused by drought. Moreover, height growth of regenerating ponderosa pine, western larch, Douglas-fir, and western white pine in areas grazed by cattle and wildlife exceeded height growth in areas used only by wildlife. No significant differences were found in survival or height growth of planted conifers in areas seeded to grass and grazed, compared to areas unseeded and grazed. Krueger (1983) speculated that even though seeded species were more productive than native understory plants, cattle grazing in seeded areas reduced transpirational losses, such that moisture stress on trees was apparently similar in seeded and unseeded areas.

Grazing animals may also control competitive woody shrubs in conifer plantations, particularly if grazing is combined with domestic forage seeding. For example, McDonald (1986) reported that seeded and native grasses significantly reduced woody shrub invasion on ponderosa pine plantations in northern and central California. McDonald (1986) further noted that controlled livestock grazing seemed to favor the establishment of grass and to prohibit new shrubs. Close co-operation between range managers and foresters could mean that young conifer plantations will be more productive because the grasses exclude new shrubs, and livestock may prevent old shrubs from expanding or producing seeds (McDonald 1986).

These potential positive interactions between livestock grazing and timber production challenge foresters and agrologists to manage more effectively for multiple use. Successful multiple-use management, however, requires that undesirable interactions between forestry and range management be minimized. For example, on poor sites with shallow soils, McDonald (1986) cautioned that no benefits to ponderosa pine seedlings would be gained by seeding domestic grasses, which often compete for moisture throughout the soil profile. Optimal management prescriptions, therefore, must be based on site-specific information, and should avoid generalities and over-simplification.

4 CONSTRAINTS TO INTEGRATED MANAGEMENT

These previous examples of successful integrated management suggest that multiple-use goals of timber and livestock production are biologically possible. Successful multiple use, however, depends not only on biological potential, but also on social, political, administrative, and economic constraints. Moreover, personal bias for or against particular resource values such as timber or cattle also influences personal commitment to integrated management. The following discussion summarizes the primary constraints to integrated resource management in the southern interior, as perceived by foresters, agrologists, and ranchers. This discussion represents the author's conclusions about the beliefs of these groups, based primarily on interviews during the field trip. Personal biases and perceptions, however, are difficult to summarize accurately. These summaries should, therefore, be used only as general information.

Most foresters believe that successful integrated management of timber and cattle could be enhanced most with improved communications. For example, new plantations, either planted or natural regeneration, are particularly vulnerable to trampling damage by cattle. Often, while moving to other pastures, cattle congregate on such plantations to bed, rest, or feed. Under these conditions, serious tree seedling damage usually occurs. Foresters generally agree that such congregation problems are difficult to overcome, even with improved communication, as many ranches are too small economically to hire range riders.

Agrologists and ranchers also believe that improved communication would promote better integrated management. Logging occasionally occurs without advance warning, which disrupts current grazing management programs. Similarly, the planting of clearcuts without proper notice reduces a rancher's ability to change traditional grazing management to protect the new plantation.

Enhanced communication among foresters, agrologists, and ranchers will require an increased commitment not only of time, but also of public and private financial resources. Even with better communication, however, compatibility between grazing and timber production may still be limited or precluded on some sites or ecosystem associations because of ecological or managerial constraints. Indeed, the difficulty of attaining integrated resource management goals varies widely, depending on ecological and financial feasibility. This report focuses on those research programs most likely to provide the biological and economic information necessary to implement integrated forest and range management.

A serious difference of opinion exists regarding the potential for simultaneous production of timber and livestock on forest plantations. Some foresters, agrologists, and ranchers believe that new research is unnecessary, suggesting that many of the negative interactions between cattle and timber could be controlled simply by not grazing new plantations during the period when trees are most vulnerable to damage. Agrologists, ranchers, and some foresters, however, believe that both cattle and timber production can be achieved throughout the life of a plantation with moderate, acceptable levels of tree damage, and maybe even with enhanced tree growth. These different opinions reflect personal experience and professional background, but are not determined just by an individual's association with timber production or livestock production. Rather, the disagreements arise primarily from insufficient biological information. Collecting this information is , therefore, important in identifying the significance of forage seeding and cattle grazing to the forest backlog and NSR problem. Ultimately, this information will provide grazing management prescriptions that increase the biological and economic yield of integrated livestock grazing and timber production in British Columbia.

5 POTENTIAL RESEARCH TOPICS

Interviews, conducted during the field trip and by telephone, identified a variety of research topics related to integrated management of livestock and timber on regenerating clearcuts. These recommended research topics generally supported the conclusions reached by previous investigations of grass/tree/cattle interactions in British Columbia. Nordstrom (1984), for example, provided an extensive literature review of forest grazing research throughout North America, and made several research recommendations relevant to British Columbia. The Forest and Grazing Task Force, (Rieche *et al.* [1984]) interviewed resource management personnel, seeking perceptions and information on grass/tree/cattle interactions in British Columbia.

Vyse (1986) conducted a workshop which developed a list of research priorities to address the backlog problem, and also provided summary lists of research topics drawn up by the Southern Interior Silviculture Committee (SISCO) and the Nelson and Kamloops Regional Research Advisory Committees (RRAC). These research topics — silvicultural in nature — included grass/tree/cattle interactions in the IDF, MS, SSBS, ICH, and ESSF biogeoclimatic zones. Wikeem (1983) also prepared a list of research priorities for the Ministry of Forests, based on a combined assessment of RRAC reports, literature review, and interviews.

The following list of potential research topics falls broadly into six categories:

1. Competition between trees and herbaceous plants.
2. Effects of livestock damage on tree survival and growth.
3. Management prescriptions for forage seeding.
4. Prescriptions for cattle management.
5. Interactions between silvicultural and grazing activities.
6. Resource economics.

There is no priority to the categories. Within each broad topic, specific research objectives are provided for clarification. These objectives reflect topics recommended during the current investigation (Pitt), and by Wikeem (1983), Nordstrom (1984), Rieche *et al.* (1984), or Vyse (1986). For comparison and cross-referencing, these sources of research hypotheses are indicated parenthetically by the abbreviations P, W, N, R, and V respectively.

5.1 Competition Between Trees and Herbaceous Plants

Wikeem (1983), Nordstrom (1984), Rieche *et al.* (1984), and Vyse (1986) all identified this topic as a research priority. The current study also verified that more information is required about the effects of herbaceous competition on trees, as virtually all interviewees indicated that insufficient data are available on which to base management decisions.

McDonald (1986) observed that the presence of grasses in young conifer plantations often leads to conflicting points of view. Grasses may hinder conifer seedling establishment by pre-empting resources, allelopathy, attracting insects and animals, and increasing fire potential. Alternatively, grasses may help established conifer seedlings in young plantations by excluding competitive plant species, and by reducing the vigour of competitive plant species through allelopathic effects (McDonald 1986). Primarily from research in eastern Oregon, central and northern California, and Arizona, McDonald (1986) concluded that grasses generally are undesirable in conifer plantations less than 5 years old. In plantations over 5 years old, on good sites with deep soils, McDonald (1986) hypothesized that grasses may be beneficial to conifer growth by excluding deeper-rooted shrubs.

In British Columbia, few experimental data exist which quantify the competitive impacts of either domestic forages or the native pinegrass on the establishment, survival, and growth of regenerating conifers. Clark and McLean (1975), in a laboratory study, concluded that survival, height, and plant mass of lodgepole pine decreased significantly as density of orchardgrass increased. Moreover, greater competition to lodgepole pine occurred with the domestic orchardgrass, a non-rhizomatous plant, than with pinegrass, a weakly rhizomatous plant.

Nicholson (1986) reported that stand survival of Douglas-fir seedlings was not correlated significantly with pinegrass density, even though pinegrass maintained a higher daily transpiration rate during times of relative drought. The reports of Nicholson (1986) and Clark and McLean (1975) conflict with the belief, widespread among field personnel, that pinegrass competes seriously with regenerating conifers. Such inconsistencies prevail because of the paucity of experimental information, which leads directly to general disagreements about the effects of grass seeding programs on backlog NSR.

Research Objectives

1. To determine the relative effects of competition with native and domestic forages on physiology, survival, and growth of lodgepole pine, Engelmann spruce, and Douglas-fir, as influenced by soil moisture availability (P, W, N, R, V).
2. To determine the relative effects of density and production of native and domestic forages on lodging of lodgepole pine, Engelmann spruce, and Douglas-fir (P).
3. To determine the relative effects of shading by native and domestic forages on germination and establishment of lodgepole pine, Engelmann spruce, and Douglas-fir (P, N).
4. To determine whether competition with herbaceous vegetation differs for planted and naturally regenerating trees (P).

Domestic forages used in the research program should include grasses and legumes, which may produce variable impacts on tree growth and survival, even at comparable densities and production levels. Ideally, the research should assess competition at variable levels of soil moisture availability. For example, competition for moisture may intensify not only during periods of drought, but also during periods of high moisture availability, which may promote increased growth of herbaceous vegetation, thereby further reducing soil moisture available for tree growth.

The research should also address potential silvicultural benefits derived from herbaceous competition, such as thinning dense stands of natural regeneration, and reducing establishment or growth of other competing plant species, particularly woody vegetation. Other such benefits of seeding grasses and legumes might be enhanced edaphic characteristics, including improved soil structure, reduced soil erosion, improved soil moisture holding capacity, and increased levels of organic matter, cation exchange capacity, and nitrogen fixation.

5.2 Effects of Livestock Damage on Tree Survival and Growth

Livestock damage to regenerating trees in British Columbia usually occurs by coincidental trampling rather than by direct browsing. This trampling damage produces basal scarring and deformed leaders which may reduce tree survival and growth. Nonetheless, no information is available from British Columbia which documents either the extent of observed basal wounding caused by livestock, or the impacts on tree growth of such basal wounding.

Sullivan and Sullivan (1982) and Sullivan (1984) investigated the impacts of basal scarring by red squirrels and snowshoe hares on thinned lodgepole pine in central British Columbia, and concluded that semi-girdling suppressed diameter growth in the first 3 years. Somewhat surprisingly, the total amount (cm^2) of bark and vascular tissue removed was not correlated significantly with lodgepole pine growth rates. Biological relationships between basal wounding and tree growth are obviously complex, and should be elucidated further.

Research Objectives

1. To determine the short- and long-term effects of basal scarring by cattle on survival and growth of lodgepole pine, Engelmann spruce, and Douglas-fir (P, N, W).
2. To derive an efficient, practical, reliable technique for measuring and rating cattle damage to trees (P).

3. To determine the age and phenological stage at which lodgepole pine, Engelmann spruce, and Douglas-fir are most susceptible to basal scarring and reduced growth rates (P).
4. To determine the proportion of annual basal scarring caused by cattle (P, W, N).
5. To assess the potential silvicultural benefits of cattle trampling damage, which may thin dense stands of natural regeneration (P, N).

5.3 Management Prescriptions for Seeding Forages

Several bulletins are available which recommend forage seeding rates, mixes, and season of seeding on disturbed forest land in British Columbia. Nordstrom (1984), however, noted that most seeding recommendations are based on experience and professional observation rather than on controlled, experimental research; and that most are confined to the IDF and PPBG biogeoclimatic subzones. Even where experimentation did occur, results were usually confounded by site or weather patterns. Consequently, more information is required for seeding guidelines, particularly so that recommendations can be made for specific biogeoclimatic zones and subzones.

Research Objectives

1. To establish appropriate rates, seasons, and mixtures of well-adapted domestic forages for seeding clearcuts, particularly in the BWBS, ESSF, ICH, MS, and SBS biogeoclimatic zones (P, W, N, V).
2. To determine the minimum amount of mineral soil exposure, and subsequent maximum time following logging, at which successful seeding of domestic forages can be obtained (P, W, N).

5.4 Prescriptions for Cattle Management

Nordstrom (1984) concluded that where extensive cattle damage has occurred on lodgepole pine/Engelmann spruce plantations in the southern Interior, poor cattle management was usually at fault. The interviews conducted during this investigation supported Nordstrom's (1984) observations. Interviewees generally believed that good cattle management included intensive grazing for short periods of time, on a sufficient number of cutblocks, such that (1) entry and removal of cattle are accomplished at specific phenological stages of tree and herbaceous plant growth, (2) livestock are dispersed with fencing, riding, salting, or water, and (3) preferred forages are abundant, to meet the needs of livestock.

Developing grazing management prescriptions to minimize trampling damage to trees, demands explicit knowledge of the interrelationships among forage production, forage utilization, plant phenology, animal behaviour, forage selection, and subsequent trampling damage. Such information is currently unavailable for British Columbia, and should be documented for those forest ecosystems where grazing on clearcuts is perceived to contribute to backlog NSR, most notably the ESSF, ICH, IDF, MS, and SBS biogeoclimatic zones.

Research Objectives

1. To develop grazing prescriptions by assessing the relative influences of cattle stocking rates, grazing duration, grazing season, forage production, forage utilization, and grass density on tree physiology, growth, and mortality (P).
2. To determine the potential of specialized forms of grazing management, such as rest- or deferred-rotation grazing, for reducing trampling damage to trees on regenerating clearcuts (P).
3. To determine the age, gender, and class of cattle which minimize trampling damage on regenerating clearcuts (P).
4. To determine the influences of cutblock size and spatial distribution of cutblocks on trampling damage by livestock (P).

These research programs will provide information which can also be applied to more general aspects of grazing management, such as the relationships among forage availability, cattle movements, and the areas within cutblocks that are preferred by cattle for bedding, resting, and grazing. Specifically, this research will allow development of grazing prescriptions that enhance or promote integrated forest and grazing management.

5.5 Interactions Between Silvicultural and Grazing Activities

Integrated forest and range management can be achieved with a wide variety of silvicultural, agronomic, and livestock management techniques. Choosing among these various alternatives assumes a thorough understanding of the biological interactions among site preparation techniques, seeding techniques, forage growth, tree growth, and livestock grazing. The following research objectives address those management options that were most often identified by the interviewees as operationally desirable or feasible.

Research Objectives

1. To determine whether acceptable forage yield can be achieved with initially low seeding rates that minimize herbaceous competition to trees (P).
2. To determine the annual trend in grass production on seeded and unseeded clearcuts, with and without cattle grazing (P).
3. To determine whether cattle grazing can be timed with plant phenology to prevent domestic forages from producing mature seed, thereby reducing future plant density and competition to trees (P).
4. To document the potential for using livestock grazing to reduce herbaceous and shrubby plant competition with regenerating trees (P, W, R).
5. To determine the relationships between canopy closure and forage production so that the need for alternative sources of forage can be predicted and allocated from areas other than new clearcuts, particularly during the critical stages of tree susceptibility to trampling damage (P, W).
6. To determine the contribution of seeded legumes to total soil nitrogen and subsequent tree growth (P, W, N).
7. To document germination, establishment, mortality, distribution, and population dynamics of seeded forages over time, particularly in relation to forage production, tree growth, and tree mortality (N).
8. To determine the optimum combination(s) of site preparation techniques, season and rates of seeding, and tree planting techniques to achieve desired levels of tree survival, tree growth, forage establishment, and forage production (R, W, V.)
9. To determine the effects of herbicide treatments on reducing herbaceous and shrubby plant competition with trees and on subsequent forage production (P).
10. To determine the comparative diets and forage preferences of cattle on unseeded and seeded clearcuts, so that proper forage use and range condition guidelines can be developed for forest grazing systems (P, W, N).
11. To determine the effects of cattle on soil compaction, structure, and nutrient cycling, particularly on subalpine fir types (P, W).

5.6 Resource Economics

Economic analyses of resource management alternatives are essential if the results of biological research are to be applied operationally. Rieche *et al.* (1984) noted that existing forest grazing research is often conducted without economic analyses to identify costs and benefits of alternative management options. Economic trade-offs are a major source of conflict between timber and grazing objectives. Such conflicts will likely intensify, even with greater understanding of biological forest/range interactions, unless the following economic considerations are addressed.

Research Objectives

1. To document the economic cost to timber production of reduced height and diameter growth of tree seedlings due to grass competition and cattle damage (P, N).
2. To document relative cattle weight gains on clearcuts seeded to domestic forages, compared to cattle weight gains on native forage (P, N).
3. To assess the economic value of increased forage production and nutritional quality of domestic forages seeded on clearcuts, compared to native forages on clearcuts (W).
4. To determine benefit/cost ratios of thinning trees to improve tree and forage production (W).
5. To determine benefit/cost ratios of cross-fencing and range riders to reduce tree mortality and trampling damage by cattle (P).
6. To determine any economic benefits to timber production of (i) reduced competition between trees and herbaceous plants because of livestock grazing, and (ii) thinning of dense natural regeneration because of herbaceous plant competition or cattle damage (P, N, R).
7. To compare total economic return from combined forestry and grazing activities with economic returns derived solely from either forestry or grazing (P, N).

6 CRITERIA FOR RANKING POTENTIAL RESEARCH

The following list of criteria for establishing priorities among alternative research projects is based on explicit and implied objectives of the 1985-1990 Forest Resource Development Agreement (FRDA); guidelines provided by the B.C. Ministry of Forests, Research Branch (MOF); and items emphasized by interviewees during the current investigation (I).

1. The research should provide information immediately useful for integrated forest and range management (I, MOF).
2. The research should provide information that is currently incomplete or lacking (I, MOF, FRDA).
3. The research should be inexpensive relative to anticipated benefits (I, MOF).
4. The research should address topics and goals that are relevant to operational forestry and grazing activities (I).
5. The research should provide results that can be related to similar ecological sites (biogeoclimatic zones) throughout the Cariboo, Kamloops, and Nelson Forest Regions (I).
6. The research should provide information directly pertinent to NSR and backlog reforestation problems (I, MOF, FRDA).
7. The research should fall within the legislative responsibility of the Ministry of Forests (MOF).
8. The research should be a logical sequence of scientific inquiry (MOF, FRDA).
9. The research should address issues where improved management depends on the information produced (MOF).
10. The research should stress information that can reduce controversy and differences of opinion about cattle, forage seeding, and NSR/backlog reforestation problems (MOF, FRDA).
11. The research should relate to social demands and/or concerns (MOF).
12. The research should have educational, extension, and demonstration values (I, MOF, FRDA).
13. The research should have a high probability of success (MOF).
14. The research should be completed within 4 years (MOF, FRDA).
15. The research should improve the effectiveness of backlog reforestation by identifying silvicultural obstacles to reforestation (FRDA).

16. Appropriate and sufficient personnel, equipment, facilities, organizations, and locations should be available to conduct the research (MOF).

Although this list of criteria provides priority guidelines for initiating potential research projects, some personal subjectivity is still required to decide which criteria are most important for ranking grass/tree/cattle interaction research. Priority rankings will, therefore, almost certainly vary among individuals. Based on a subjective synthesis of the information needs identified by resource managers during the interviews, consistency with previous research recommendations, research guidelines provided by Ministry of Forests, Research Branch, and objectives of FRDA, the research programs recommended in Section 7 emphasize the following five criteria:

1. The research addresses those issues of greatest controversy and disagreement among resource managers.
2. The research provides information directly pertinent to reducing the NSR and forest backlog problems.
3. The research improves the effectiveness of operational backlog reforestation by identifying silvicultural obstacles to reforestation.
4. The research demonstrates the effectiveness of reforestation programs in field locations.
5. The research supports or supplements current research programs and activities, and provides information currently lacking or incomplete.

7 RECOMMENDED RESEARCH

The five primary criteria listed in Section 6 are not necessarily all addressed optimally with research in the strictest sense of hypothesis testing and replicated treatments. For example, potentially effective integrated forest and range management opportunities may be demonstrated best with operational programs, rather than with small-scale experimental plots. Successful applied-research endeavours must often compromise the objectives of rigorous experimental design to maintain relevancy with operational forestry and grazing activities. The following research programs (Sections 7.1 - 7.5), listed in recommended order of priority, necessarily reflect such compromises.

7.1 Research and Demonstration of the Impacts of Operational Cattle Grazing and Forage Seeding on Reforestation

Rationale

Virtually all interviewees identified demonstration projects as the single most effective means by which to determine the impacts of operational livestock grazing and forage seeding activities on backlog reforestation. Moreover, the current investigation supports the conclusions of Wikeem (1983), Nordstrom (1984), Rieche *et al.* (1984), and Vyse (1986) that insufficient data are available on which to base management decisions regarding biological interactions among domestic forages, livestock grazing, and regenerating conifers. No conclusive experimental evidence exists which documents (1) the relative competitive abilities of pinegrass and domestic forages, such as clovers, crested wheatgrass, orchardgrass, smooth brome, and timothy; (2) the proportion of damage to regenerating trees (Douglas-fir, Engelmann spruce, and lodgepole pine) caused by livestock grazing; or (3) the effect of livestock damage on tree survival and growth. This lack of specific information contributes directly to the controversy surrounding the impact of grazing activities on backlog reforestation.

Baloc *et al.* (1986) indicated that conclusive, replicated results from operational forestry and grazing studies are difficult to achieve. Such difficulty reflects the myriad factors affecting tree survival and growth, including herbaceous and shrubby plant competition, cattle stocking rates, length of grazing period, grazing season, forage production, forage utilization rates, forage density, plant phenology, and climatic variability.

Theoretically, all of these factors could be analysed factorially, such that specific forage and grazing management programs could be equated to specific rates of tree survival and growth. Economic and logistic restrictions, however, preclude such extensive factorial research programs. Therefore, rather than

following a strict experimental approach, these demonstration projects should strive to assess relative influences of operational grazing and forage seeding on tree survival and growth. For example, exclosures within grazed clearcuts could be used to identify the proportion of basal scarring caused by cattle. Such exclosures could be partitioned, with sub-portions being seeded alternatively to domestic forages, while the remaining portions are left in native forages. This partitioning permits assessment of the effects of plant competition on tree survival and growth, as well as of the potential of cattle to increase tree survival and growth by reducing herbaceous plant competition.

These research and demonstration projects of operational range management programs satisfy all criteria listed in Section 6, except that more than 4 years would likely be required to achieve all the research objectives. Nonetheless, all of the infrastructure and capital spending will be completed by 1990, so that the demonstration results will remain available and visible after the FRDA project is terminated. These results will address issues of controversy; provide information directly pertinent to backlog NSR; identify silvicultural obstacles to reforestation; supplement the inconclusive information currently available in British Columbia about grass/tree/cattle interactions; and demonstrate the potential effectiveness of reforestation programs in combination with cattle grazing and forage seeding.

Objectives

1. To determine the relative effects of domestic forage and native vegetation on survival and growth of crop trees in the presence and absence of grazing by domestic livestock.
2. To assess the proportion of physical damage caused by cattle to regenerating conifers.
3. To identify those cattle grazing factors most likely responsible for tree damage and mortality within various biogeoclimatic subzones.

7.2 Effects of Basal Scarring and Shoot Damage on Lodgepole Pine and Spruce Seedling Survival and Growth

Rationale

Widespread disagreement and uncertainty exist about the effects of basal scarring on tree survival and growth, not only between agrologists and silviculturalists, but also among silviculturalists. Although wounding likely produces some initial decline in growth rates, no data are available which describe functional relationships among wounding severity, growth reduction, and survival of Engelmann spruce and Douglas-fir. This research project will supplement existing information on lodgepole pine wounding by red squirrels and snowshoe hares (Sullivan and Sullivan 1982; Sullivan 1984), and will lead directly to identifying the impact of cattle trampling damage on reforestation.

Wikeem (1983) and Nordstrom (1984) also identified the effects of livestock damage on tree survival and growth as an important research topic. Moreover, this research program satisfies all of the criteria listed in Section 6, except that more than 4 years would be required to document fully the impacts of wounding on long-term tree growth rates. This single exception, however, should not preclude the research. Some of the most important information, such as the time required to reach the free-to-grow stage or the impact on rotation age, can be determined only with long-term studies.

This research program is ranked as a second priority because it is less controversial and provides fewer demonstration values than the previous project. Nonetheless, clarifying the effects of livestock damage on tree survival and growth will certainly improve the effectiveness of operational backlog reforestation, and will provide information currently lacking or incomplete. The study sites can also be used to demonstrate the effectiveness of reforestation programs in field locations.

Objectives

1. To determine the effects of different levels of seedling girdling on tree survival and growth.
2. To determine the effects of different levels of shoot removal on tree survival and growth.
3. To determine the effect of season of damage on tree survival and growth.
4. To determine the effect of girdling and shoot removal on seedlings of two different age classes.

7.3 The Effects of Grazing Pressure on Conifer Seedling Damage

Rationale

Specific grazing management programs that minimize damage to regenerating trees still remain largely unknown or unverified in British Columbia. Specific management suggestions include intense grazing with high forage utilization for short grazing periods, moderate forage utilization for short grazing periods, and moderate forage utilization for extended grazing periods. Another hypothesis is that grazing can not occur on new plantations without resulting in unacceptable trampling damage to trees. Obviously much controversy still remains, and new research is required to establish the relationship between NSR and backlog forest sites with specific grazing management programs. This research should extend the work of McLean and Clark (1980) to a variety of biogeoclimatic zones (e.g., PPBG, ICH, IDF, ESSF, MS), which will improve the effectiveness of reforestation and operational management programs throughout the southern Interior.

This research is logistically and experimentally more difficult to achieve than any of the other four research proposals. Nonetheless, investigating the effects of grazing pressure on conifer seedling damage addresses a highly controversial issue, provides information directly pertinent to reducing NSR and backlog, and offers the best potential for yielding information that can be immediately and directly useful to integrated forest and range management.

Previous research on forest grazing in British Columbia has focused independently on manipulating stocking rate or duration of grazing to determine potential impacts on regenerating conifers. However, the true cause of trampling damage likely correlates with grazing pressure, which reflects the amount of searching effort required by cattle to satisfy their forage needs.

Grazing pressure describes the instantaneous ratio of animal demand per unit weight of forage at any time (Scarnecchia 1985). It combines both the number of livestock on a unit area and the duration of the grazing period. Theoretically, grazing pressure and seedling damage are directly related, although this relationship has not been confirmed. For example, equal indices of grazing pressure can be achieved by altering the combination of animal numbers and duration of grazing (i.e., 200 animals X 14 days grazing would produce the same grazing pressure as would 100 animals for 28 days), but these combinations may not result in the same seedling damage.

Objectives

The study will be approached in two phases. In the first, the objectives are:

1. To determine the grazing pressure threshold that results in physical damage to conifer tree seedlings.
2. To confirm that equal levels of grazing pressure produce the same levels of seedling damage.
3. To determine the relationship between percent utilization of forage and grazing pressure, to provide a more convenient method for managers to assess potential damage to tree seedlings and alter cattle management.

The objectives of the second phase will be:

1. To repeat the research in all important subzones where cattle use may be a factor in backlog.
2. To develop management prescriptions for cattle use on plantations, on a subzone basis.

7.4 Effects of Forest Herbicides on Survival and Production of Key Herbaceous Species

Rationale

This research topic was not previously identified by Wikeem (1983), Nordstrom (1984), Rieche *et al.* (1984), or Vyse (1986). Recently, however, increasing use of herbicides to control competing woody and herbaceous vegetation on regenerating clearcuts has prompted greater interest in this topic, such that similar studies were initiated in the Kamloops Region in 1986. This research topic satisfies most criteria listed in Section 6, and it can be completed in 4 years. Although its research objectives are currently less controversial than those in other issues, and do not contribute directly to reducing NSR and backlog problems they do supplement existing research programs, and provide information currently unavailable.

This information will enhance integrated forest and range management by identifying the potential negative impacts of herbicide use on forage production. Such impacts not only affect the livestock industry, they also influence wildlife habitat quality. Such considerations are directly pertinent to the British Columbia *Forest Act*, which seeks to "encourage maximum productivity of the forest and range resources in the Province."

Objectives

1. To determine the effect of Roundup® on the survival and production of key herbaceous plant species.
2. To develop stocking level guidelines based on the changes in forage production levels following herbicide application.
3. To enhance long-term planning for re-allocation of AUM's of grazing in forested areas treated by herbicides.

7.5 The Effects of Cattle Grazing and Forage Seeding Rates on the Survival and Growth of Conifers and Control of Native Vegetation

Rationale

A primary objective of the FRDA program is to focus on the renewal of backlog NSR with increased intensive silviculture (Prov. Brit. Col. and Govt. Canada 1986). This objective requires that silvicultural recommendations resulting from the FRDA program be based on reliable, conclusive information and research. Although demonstration projects may provide operational comparability, they often fail to yield statistically or scientifically conclusive results. Therefore, demonstration projects should be supplemented and confirmed with experimentally rigorous research programs.

This research proposal provides experimental support for the demonstration project in Section 7.1, which investigates the effects of cattle grazing and forage seeding on reforestation. The proposal, therefore, satisfies similar criteria, but is confined to a single research site to achieve replication of experimental units. The project is ranked fifth in priority primarily because of its greater cost, the logistic difficulties with experimental animals, and the few replications that will be possible which increases the potential for experimental error. Because of this limited number of replications, this proposal poses the most likely source of inconclusive results.

Nevertheless, this research project is necessary for the FRDA program to produce scientifically credible results on the effects of cattle grazing and forage seeding on conifer survival and growth. Such information will significantly enhance the effectiveness of backlog reforestation programs, and will also demonstrate such effectiveness at the research site.

Objectives

1. To determine the effect of four seeding rates on suppressing native vegetation, and the subsequent benefits to conifer survival and growth.
2. To determine the effect of three levels of grazing intensity on suppressing native vegetation and the survival and growth of conifers.
3. To develop management prescriptions for seeding rates and cattle use on seeded plantations.
4. To determine the effects of variable seeding rates on plant density and forage production.
5. To determine the effects of variable grazing intensity and forage production, as influenced by seeding rates, on cattle weight gains.

8 IMPLEMENTING THE RESEARCH RECOMMENDATIONS

The recommended research and demonstration projects include only a small fraction of potentially useful topics identified in Section 5. Depending on availability of funds, additional topics might also be considered, some of which could be perceived as more important or urgent than those recommended in Section 7. Consequently, before any research begins, the recommendations listed above should be reviewed by all research participants, who should provide at least a consensus of approval for the collective research program.

8.1 Research Participants and Administration

The scope of the proposed research and demonstration projects necessarily requires a research team to distribute the effort among several participants. These participants should represent all affected parties, including silviculturalists and range agrologists. Ideally, the research team should include resource managers as well as scientists. Specific research projects, including objectives, procedures, and intended results should be discussed and approved by the entire team. This approach ensures that the research will satisfy scientific credibility while still producing information with practical application.

Team research provides disadvantages as well as advantages. Because research responsibilities are often compartmentalized, team research programs tend to evolve into several research programs reflecting the interests, goals, and abilities of individual scientists. This occasionally compromises the original objective for a cohesive, singular endeavour. Strong, administrative leadership is necessary to minimize these evolutionary tendencies. The research program should, therefore, be administered and controlled by a single agency, preferably a single individual. The Ministry of Forests, Research Branch, is likely the most suitable administrative agency, not only because of its primary function for research, but also because of its implicit neutrality in forestry and livestock interests.

Research administration should adopt the hierarchical format that includes a Steering Committee, Management Committee, Program Manager, and Project Leaders. Participants at these various levels should reflect current government policies and procedures, although the Management Committee should include representatives of government, ranchers, and private timber companies.

The administrative structure of the research team, including specific membership on the Steering and Working Committees, should be established quickly, as these committees should be functional when FRDA funding is approved. The initial responsibilities of these committees should be to:

1. identify potential Program Managers and Project Leaders;
2. approve or amend the research and demonstration projects recommended in Sections 7.1-7.5;
3. request working plans for the approved or amended research and demonstration projects;
4. assign financial support to the approved or amended research and demonstration projects;
5. allocate responsibility for specific research and demonstration projects, through consensus, administrative decision, or competitive bidding.

Responsibilities for specific research and demonstration projects should be allocated according to scientific expertise and interest. Periodic meetings of all Project Leaders should be held to discuss progress and recommended changes in methodology or objectives. No changes should occur without approval of the Management Committee, in consultation with the other Project Leaders. Progress reports should also be presented to the Management Committee, at prescribed intervals throughout the FRDA program.

8.2 Working Plans

Working plans are particularly important, and should be developed meticulously, despite the relative short time-frame of FRDA. Many previous field research projects have produced inconclusive results because too little attention was paid to appropriate statistical hypotheses (Romesburg 1981) and experimental design, particularly the need for treatment replication (Hurlbert 1984; Stroup *et al.* 1986). These treatment replications, which are necessary so that the results can be extrapolated to other ecologically similar sites within the same biogeoclimatic zones or subzones, are notably missing from many grazing studies (Stroup *et al.* 1986).

This FRDA project must not suffer from the same inconclusiveness, particularly since the results are needed so urgently to identify and reduce the potential impact of grazing activities on backlog NSR. No research should begin before the working plan is complete, including research objectives, statistical hypotheses, experimental design, proposed statistical analyses, specific research sites, detailed research budget, and anticipated results. Demonstration projects should also follow this procedure, and must justify, where necessary, those aspects of the investigation that may be exempted from treatment replication, because of logistic or economic constraints. Development of these working plans, with subsequent approval by the Management Committee, may mean that some intensive research will not begin until the 2nd year of FRDA support.

Quantitative, statistical hypotheses may be derived or inferred from the research objectives listed in Sections 7.1 - 7.5. These hypotheses may be refined further by referring to Nordstrom's (1984) literature review, or by investigating SX silviculture trials and Ministry of Forests records on site preparation treatments, seeding and planting procedures, herbicide applications, and grazing programs. Assessing the effects of these factors on conifer survival and growth, perhaps with multivariate statistical techniques, may help establish the most appropriate sites, levels of grazing, rates of seeding, rates of herbicide application, tree species, levels of tree seedling wounding, and biogeoclimatic zones for the general research objectives identified in Sections 7.1 - 7.5.

8.3 Location of Research

The Kamloops Forest Region seeds approximately 25.9% of all disturbed forest land to domestic forages, compared to only 6.1 and 18.7% for the Cariboo and Nelson Forest Regions, respectively (Table 9; Section 3.3.1). Presumably, seeded areas are also grazed, suggesting that grazing activities are more likely associated with NSR backlog in the Kamloops Forest Region than in either the Cariboo or Nelson Forest Regions. Indeed, livestock grazing occurs on only 8% of forest land in the Nelson Forest Region, further suggesting that most NSR in this region results from causes other than grazing activities. Consequently, the research and demonstration projects recommended in Sections 7.1 - 7.5 should likely occur primarily within the Kamloops Forest Region.

Results from research and demonstration in the Kamloops Forest Region may be extrapolated to equivalent biogeoclimatic zones and subzones in the Cariboo and Nelson Forest Regions. Table 1 (Section 3.1) illustrates that the proportion of total backlog NSR in the Kamloops Forest Region is highest in the ESSF (37%), IDF (29%), ICH (18%), and MS (13%) biogeoclimatic zones.

Unfortunately, the General Range Types within which the extent of livestock grazing is generally summarized do not correlate directly with biogeoclimatic zones. Definitive conclusions about the zones used most intensively for livestock grazing are therefore not possible. However, interviewees during the current investigation generally indicated that dry subzones of the ESSF, ICH, IDF, MS, and PPBG are likely most susceptible to NSR backlog caused by livestock grazing and seeding of domestic forages. The research and demonstration projects recommended in Sections 7.1 - 7.5 should likely occur primarily within representative examples of these dry subzones, particularly those used commonly for livestock grazing on clearcuts throughout the Cariboo, Kamloops, and Nelson Forest Regions.

Wherever possible, demonstration and research sites should be co-ordinated with current operational and scientific studies. For example, Mr. Bob Christie, of Gorman Brothers in Westbank, has established operational study sites from which data have already been collected. Mr. Christie is enthusiastic about the opportunity to combine his efforts with future FRDA projects.

Similar co-operative opportunities exist in Forest Regions other than Kamloops. Mr. Randy Trewise, of Pope & Talbot in Midway, has also established operational study sites, with preliminary information already available on the effect of livestock grazing and forage seeding on tree survival. Like Mr. Christie, Mr. Trewise welcomes the potential for supplemental, more intensive research. The FRDA project should capitalize on such co-operative opportunities, particularly in the Nelson Forest Region, where very little information is currently available.

The Cariboo Forest Region also suffers from a lack of specific information about the interactions among grass, trees, and cattle. The small proportion (6.1%) of disturbed forest land in that Region currently seeded to forages is perceived by some agrologists to reflect reluctance on the part of foresters and silviculturalists to seeding programs. This reluctance likely results from a belief that domestic forages would provide undesirable competition to regenerating trees; and that forage seeding would encourage increased livestock grazing, with presumably negative effects on tree survival and growth.

The FRDA project should establish at least one demonstration project (Section 7.1) in both the Cariboo and Nelson Forest Regions. These projects would provide greater geographical breadth to research sites in the Kamloops Forest Region; would establish demonstration sites throughout the southern Interior, with increased local accessibility; and would expand the provincial range research effort, which has historically emphasized the Kamloops Forest Region.

8.4 Dissemination of Research Results

A major objective of the FRDA program is to improve the effectiveness of operational forestry, primarily by reducing NSR and backlog forest sites. The research and demonstration projects listed in Section 7 can not achieve this objective unless the information generated is synthesized and widely distributed. Therefore, study tours, workshops, seminars, and information bulletins which present the research findings should receive high priority for FRDA funding.

9 CONCLUSIONS

The interviews conducted during this investigation generally confirmed previous recommendations for the kinds of research programs and topics that are most pertinent to grass/tree/cattle interactions affecting backlog NSR. Nonetheless, the recommendations for specific research priorities and research sites reflect the author's opinion, and have been reviewed by the contract supervisors. These recommendations should therefore be assessed carefully by the Steering and Working Committees of the FRDA project to ensure that FRDA objectives, terms of reference, and research criteria have been accurately addressed and interpreted.

The most salient conclusion from this investigation is that virtually all interviewees identified demonstration projects, with operational grazing and forestry activities, as the most desirable mechanism by which to investigate grass/tree/cattle interactions. These demonstration projects should also be supplemented with experimentally rigorous research, which will provide scientific credibility to unreplicated, operational demonstrations. A series of operational demonstrations, repeated on as many sites as is economically feasible, and supported by intensive experimental work on a single research site, provides an optimal approach to achieving the FRDA goals of: 1) providing new information pertinent to backlog NSR; 2) improving backlog reforestation techniques; 3) reducing controversy surrounding grass/tree/cattle interactions; and 4) providing educational, extension, and demonstration values.

Research and demonstration projects that generate new information are an integral component of improved integrated forest and range management. New information, however, will not solve all problems associated with grass/tree/cattle interactions, many of which result from insufficient communication rather than lack of information. For integrated forest and range management to be successful, all resource participants must strive to minimize personal bias, and be willing to compromise specific resource objectives to achieve maximum productivity of the forest and range resources.

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APPENDIX 1. Interviewees

British Columbia Ministry of Agriculture and Fisheries
- Mr. Don Blumenauer (Agrologist, Williams Lake)

British Columbia Ministry of Forests
- Mr. Jim Hilton (Inventory, Williams Lake)
- Mr. Ray Pederson (Protection, Kamloops)
- Mr. Dick Reimer (Operations Superintendent, Penticton)
- Mr. John Wenger (District Manager, Penticton)

British Columbia Ministry of Forests, Range
- Mr. Dwaine Brooke (Kamloops)
- Mr. Dave Clark (Nelson)
- Mr. Chris Easthope (Williams Lake)
- Mr. Rob Gordon (Williams Lake)
- Mr. Glenn Heyes (Merritt)
- Mr. Jack King (Nelson)
- Mr. Larry LaCasse (Penticton)
- Mr. Tom Lester (Victoria)
- Mr. Bill McLachlan (Victoria)
- Mr. Jim Massey (Kamloops)
- Mr. Lyle Resh (Williams Lake)
- Mr. Jim White (Kamloops)
- Mr. Vic Wright (Vernon)
- Mr. Phil Youwe (Kamloops)

British Columbia Ministry of Forests, Research
- Mr. Alan Vyse (Kamloops)
- Dr. Brian Wikeem (Kamloops)

British Columbia Ministry of Forests, Silviculture
- Ms. Ingrid Davis (Merritt)
- Mr. Gene Desnoyers (Penticton)
- Mr. Bernie Ivanco (Kamloops)
- Mr. Jerome Jang (Penticton)
- Mr. Brian McNaughton (Nelson)
- Mr. Brent Olsen (Kamloops)
- Mr. Al Randall (Williams Lake)
- Mr. Jerry Wearing (Vernon)
- Mr. Yo Yano (Kamloops)

Forest Consultants
- Dr. Tom Sullivan (Langley)

Graziers
- Mr. Jake Hoogendorn (Vernon)
- Mr. Don Moses (Lower Nicola Indian Band, Merritt)

Timber Companies
- Mr. Don Banks (Balco Industries Ltd., Kamloops)
- Mr. Bob Christie (Gorman Brothers, Westbank)
- Mr. Don Couch (Riverside Forest Products, Vernon
- Mr. Bob Harrison (Crown Forest, Kelowna)
- Mr. Ernie Hayward (Aspen Planers, Merritt)
- Mr. Les Laithwaite (Weyerhauser Canada Ltd., Kamloops)
- Mr. Dennis Peaker (Weyerhauser Canada Ltd., Okanagan Falls)
- Mr. Steve Pelton (Balco Industries Ltd., Kamloops)
- Mr. Randy Trewise (Pope & Talbot, Midway)